EXHIBIT 2

FAX NOTE

Duncan - here are some words for you to pass through to your patent attorney. It is my hope that these ideas form the basis for a patent.

Please let me know how I can help get this patent written and assigned to ATML.

Bruce

Copy to MAT
JRB

1/9/95

Company

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ATMI Record of Invention #95-2
ATMI File No. 198

White Light Emitting Diodes Based on Fluorescent Impregnation
Invention Report
Prepared by: Bruce Baretz, Keen Solutions, Inc. on Jan 7, 1995

1. What Is It?

The invention relates to the utilization of a single source (typically monochromatic) light emitting diode die that activates (photoexcites) the ground state of suitable fluorophors encapsulated in a polymeric matrix (or otherwise placed in a non active region of a light emitting diode assembly) whereby these fluorophors, after photoexcitation, re-emit their absorbed energy at a wavelength and wavelengths bathochromic to the initial wavelength of emission coming from the active layer of the light emitting diode.

2. Why Is It Useful?

a. The invention allows for the use of a single light emitting diode die to emit light with "white" coloration without requiring the manufacturing of a complex set of diode dice or subassemblies, as white light emission is presently obtained by the simultaneous utilization of red, green and blue light emitting diode dies. In this invention, the white light emission can be obtained using a single light emitting diode die and a composition of a single or mixture of suitable fluorophors that emit a broad range of wavelengths thereby offering a white light. Further, these fluorophors can be selected in a manner that allows for different hues of white to be manufactured by a simple adjustment of the concentrations of the fluorescer compositions.

b. The invention also allows for the development of a single light emitting diode die, perhaps in the ultraviolet or in the blue, that can be used to prepare light emitting diode lamps of virtually any coloration or wavelength, including all shades and hues of white. Further, the invention allows for the preparation of broad band emitting light emitting diode lamps, as opposed to the current situation where monochromatic light is typically obtained.

c. The inventions allows for the utilization of light of any color and provides for a shift of the light emission to a desired spectrum, without a loss of light intensity, provided fluorophors with fluorescent quantum yields of 1.0 are utilized. Allows for better color matching of LED lamps with incandescent lamps they are designed to replace, without requiring a substantial redesign of the p-n junction. -

3. What Materials Show It?

Read and understood
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Patent & Prior Art Search: White Light Emitting Diodes based on Fluorescent Impregnation
01/08/95Date: 01-07-95

In the present invention, fluorescent dies developed for the polymorfo industry are believed to provide a suitable mixture of emission to generate white light. Further, light emitting diode dies based on GaN and SiC active layers are thought to provide suitable activation wavelengths to cause the generation of white light.

4. Prior Art *(Some relevant prior art. Full compendium is a database search submitted to ATMI on 12-20-94).*

a. white LEDs -

i. TI White light-emitting organic electroluminescent devices using the poly(N-vinylcarbazole) emitter layer doped with three fluorescent dyes.
AU Kido, J. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)); Hongawa, K. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)); Okuyama, K. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)); Nagai, K. (Department of Materials Science and Engineering, Yamagata University, Yonezawa, Yamagata 992 (Japan)).
SO Appl. Phys. Lett. (14 Feb 1994) v. 64(7) p. 815-817
Current Physics Microform No.: 9401G2156
ISSN 0003-6951; CODEN APPLAB
CY UNITED STATES
DT Journal
TC Experimental
LA English
AB White light-emitting electroluminescent devices were fabricated using poly(N-vinylcarbazole) (PVK) as a hole-transporting emitter layer and a double layer of 1,2,4-triazole derivative (TAZ) and tris(8-quinolinolato)aluminum(III) complex (Alq) as an electron transport layer. The PVK layer was doped with fluorescent dyes such as blue-emitting 1,1,4,4-tetraphenyl-1,3-butadiene, green-emitting coumarin 6, and orange-emitting DCM 1. A cell structure of glass substrate/indium-tin-oxide/doped PVK/TAZ/Alq/Mg:Ag was employed. White emission covering a wide range of the visible region and a high luminance of 3400 cd/m2 were obtained at a drive voltage of 14 V.

ii. TI Visible electroluminescence from mu c-SiC/porous Si/c-Si p-n junctions.
AU Mimura, H.; Futagi, T.; Matsumoto, T.; Katsuno, M.; Ohta, Y.; Kitamura, K. (Electron. Res. Labs., Nippon Steel Corp., Kawasaki, Japan)
SO International Journal of Optoelectronics (March-April 1994) vol.9, no.2, p.211-15. 17 refs.
Price: CCCC 0952-5432/94/$10.00
CODEN: IJOOEV ISSN: 0952-5432
DT Journal
TC Experimental
CY United Kingdom
LA English
DN A9419-7860F-007; B9410-4260D-010
AB We have fabricated two kinds of Si light emitting diodes (LEDs) consisting

of n-type microcrystalline silicon carbide (mu c-SiC)/porous silicon (PS)/p-type crystalline silicon (c-Si) p-n junctions and demonstrated a visible light emission from them. We have observed three types of visible light emission: a very weak white light emission at a forward current of about 90 mA mm-2 and a strong orange-red light emission at a forward current from 200 to 619 mA mm-2 for the Si LED using a 3.5-4.5 Omega cm c-Si substrate, and a uniform red light emission at a forward current above 12 mA cm-2 for the Si LED using a 0.2-0.4 Omega cm c-Si substrate.

AN 92:4211891 INSPEC DN B9209-4260D-010
TI Amorphous carbon basis blue light electroluminescent device.
AU Yoshimi, M.; Shimizu, H.; Hattori, K.; Okamoto, H.; Hamakawa, Y. (Fac. of Eng. Sci., Osaka Univ., Japan)
SO Optoelectronics - Devices and Technologies (June 1992) vol.7, no.1, p.69-81. 20 refs.
CODEN: ODTEEG ISSN: 0912-5434
DT Journal
TC Practical; Experimental
CY Japan
LA English
DN B9209-4260D-010
AB Blue light emission has been observed in hydrogenated amorphous carbon (a-C:H) basis multilayered thin-film electroluminescence (EL) mode structure. The device is composed of a-C:H/a-SiC:H active layers sandwiched between hydrogenated amorphous silicon nitride (a-SiN:H) insulating layers, all of which are prepared by RF plasma chemical vapor deposition. A series of technical data on the device performance, including luminance, transferred charge density and emission spectrum are presented. Developed devices exhibit a broad band white light emission having a luminance up to 20 cd/m2. However, purity of emission color is remarkably improved by insertion of a-SiC:H layer in the middle of the active a-C:H layer.

III. AN 92:4234151 INSPEC DN B9210-4260D-012
TI Amorphous thin film white-LED and its light-emitting mechanism.
AU Chen Zhiming; Sun Guosheng; Pu Hongbing (Shaanxi Inst. of Mech. Eng., Xi'an, China)
SO Conference Record of the 1991 International Display Research Conference (Cat. No.91CH3071-8)
New York, NY, USA: IEEE, 1991. p.122-5 of vii+257 pp. 4 refs.
Conference: San Diego, CA, USA, 15-17 Oct 1991
Sponsor(s): IEEE; SID; Advisory Group Electron Devices
Price: CCCC CH3071-8/91/0000-0122$01.00
ISBN: 0-7803-0213-3
DT Conference Article
TC Practical
CY United States
LA English
DN B9210-4260D-012
AB Thin film light-emitting diodes (TFLEDs) made of amorphous semiconductor silicon carbide (a-SiC:H) have been developed by glow discharge deposition in an SiH4+CH4 mixture. White light emission is observable in the samples with a structure of either glass/ITO/a-SiC:H/Al or glass/ITO/p-i-n a-SiC:H/Al when a proper critical condition has been established. The light-emitting mechanism associated with these LEDs is suggested to be an

irradiative recombination of the electrons in the extended states of the conduction band and the holes in the localized states of the valence band.

iv. AN 92(10):133581 COMPENDEX DN 9210131365
TI Amorphous thin film white-LED and its light-emitting mechanism.
AU Chen, Zhiming; Sun, Guosheng; Pu, Hongbing
MT Conference Record of the 1991 International Display Research Conference.
MO IEEE Electron Devices Soc; Society for Information Display; Advisory Group on Electron Devices
ML San Diego, CA, USA
MD 15 Oct 1991-17 Oct 1991
SO Conference Record of the 1991 International Display Research Conference Conf Record 91 Int Display Res Conf.Publ by IEEE, IEEE Service Center, Piscataway, NJ, USA (IEEE cat n 91CH3071-8).p 122-125
ISBN: 0-7803-0213-3
PY 1991
MN 16906
DT Conference Article
TC Experimental; Theoretical
LA English
AN 92(10):133581 COMPENDEX DN 9210131365
AB Thin film light-emitting diodes (TFLEDs) made of amorphous semiconductor silicon carbide (a-SiC:H) have been developed by glow discharge deposition in an SiH4 plus CH4 mixture.White light emission is observable in the samples with a structure of either glass/ITO/a-SiC:H/Al or glass/ITO/p-i-n a-SiC:H/Al when a proper critical condition has been established.The light-emitting mechanism associated with these LEDs is suggested to be an irradiative recombination of the electrons in the extended states of the conduction band and the holes in the localized states of the valence band.4 Refs.

v. AN 91(17):88800 PHYS
TI Blue-emitting electroluminescent phosphors: review and status.
AU Leach, S. (DavTech Inc., Princeton, NJ (USA)); Morton, D.C. (U.S. Army Electronic Devices and Technology Lab., Fort Monmouth, NJ (USA))
NR Ph--170
SO 5. International Workshop on Electroluminescence.
Leskelae, M. (Turku Univ. (Finland); Helsinki Univ. of Technology (Finland)); Nykaenen, E. (Helsinki Univ. of Technology (Finland)) (eds.)
Finnish Academy of Technology, Helsinki (Finland)
1990 p. 137-143 of 316 p.
Acta Polytech. Scand., Appl. Phys. Ser.no. 170
Conference: 5. International Workshop on Electroluminescence (EL-5), Helsinki (Finland), 11-13 Jun 1990
ISSN 0355-2721; CODEN APSSD; ISBN 951-666-317-6
CY FINLAND
DT Miscellaneous; Conference
TC Experimental
LA English
AB White TFEL has made enormous strides in the last several years. the weak point in achieving a high luminance display is the continued lack of an efficient blue-emitting electroluminescent phosphor. This paper reviews the

field of blue-emitting EL phosphors, and presents research results on one of the possible candidates for TFEL displays.

vi. AN 90:3633232 INSPEC DN B90040506
TI Toward a visible light display by amorphous SiC:H alloy system.
AU Hamakawa, Y.; Kruangam, D.; Toyama, T.; Yoshimi, M.; Paasche, S.; Okamoto, H. (Fac. of Eng. Sci., Osaka Univ., Japan)
SO Optoelectronics - Devices and Technologies (Dec. 1989) vol.4, no.2, p.281-94. 25 refs.
CODEN: ODTEEG ISSN: 0912-5434
DT Journal
TC Practical; Experimental
CY Japan
LA English
DN B90040506
AB A series of experimental trials to realize flat panel display devices using plasma CVD-produced a-Si1-xCxH alloy has been reported. Fabrication technology and basic properties of the active material a-Si1-xCxH alloy are briefly introduced. Then the technical data on both injection type and intrinsic type EL devices are presented. The injection type EL device (LED) has a basic structure of p (a-SiC:H)/i (a-SiC:H)/n (a-SiC:H), and the emission color can be controlled from red to green by adjusting the carbon content x in the a-Si1-xCxH luminescent i-layer. The luminance of 20 cd/m2 was obtained from the yellow LED with a forward injection current density of 600 mA/cm2. The intrinsic EL device (TFEL) shows a luminance of 30 cd/m2 for the blue color emission and 40 cd/m2 for white light so far. The developed devices have some significant advantages over the conventional crystal LEDs: wide area, ease of fabricating integrated type multi-color or tunable color LEDs, and low cost. Utilizing these characteristics, new types of optoelectronic functional elements are proposed and discussed.

vii. AN 86(16):77843 PHYS
TI White light emitting thin-film electroluminescent devices with SrS:Ce, Cl/ZnS:Mn double phosphor layers.
AU Tanaka, S.; Mikami, Y.; Deguchi, H.; Kobayashi, H. (Dept. of Electronics, Tottori Univ. (Japan))
SO Jpn. J. Appl. Phys., Pt. 2. (Mar 1986) v. 25(3) p. L225-L227
ISSN 0021-4922; CODEN JAPLD
CY JAPAN
DT Journal
TC Experimental
LA English
AB White light emitting thin-film electroluminescent devices have been fabricated. The devices consist of double phosphor layers of a greenish-blue light emitting SrS:Ce, Cl and a yellowish-orange light emitting ZnS:Mn. A brightness level of 1100 cd/m2 at 5 KHz drive has been obtained. (orig.)

viii. AN 92-368485 [44] WPINDEX
DNN N92-279300
TI Tunnel junction multiple wavelength light-emitting diode for display system - has p-n junctions with different band gaps which may be collectively energised.

DC U12 U13
IN KURTZ, S R; OLSON, J M
PA (MIDE) MIDWEST RES INST
CYC 34
PI WO 9217909 A1 921015 (9244)* EN 11 pp
RW: AT BE CH DE DK ES FR GB GR IT LU MC NL OA SE
W: AT AU BB BG BR CA CH DE DK ES FI GB HU JP KP KR LK LU MG MW NL NO PL RO RU SD SE US
US 5166761 A 921124 (9250) 8 pp
AU 9217577 A 921102 (9305)
ADT WO 9217909 A1 WO 92-US2281 920323; US 5166761 A US 91-678230 910401; AU 9217577 A AU 92-17577 920323, WO 92-US2281 920323
FDT AU 9217577 A Based on WO 9217909
PRAI US 91-678230 910401
AN 92-368485 [44] WPINDEX
AB WO 9217909 A UPAB: 931006
A multiple wavelength light-emitting diode has a monolithic cascade cell structure comprising at least two p-n junctions with GaInP2/GaAs as top/bottom cells. This gives each junction different band gaps.
An electrical connection is then structured in place so that all of the p-n junctions are simultaneously energised to emit corresponding wavelengths or colours. A transparent tunnel p-n junction of GaAs n+/GaAs p+ interconnects the diodes.
ADVANTAGE - Provides three primary colours or emits them simultaneously to produce white light in a display.
3/5
ABEQ US 5166761 A UPAB: 931006
The multiple wavelength light emitting diode comprises a multiple layered, single structure of several LED's of varying band gaps, and is made by depositing thin films of alternating p-doped and n-doped materials, wherein the lowest band gap material is deposited first and the highest band gap material is deposited last. Electrical connections are then structured in place so that all of the n-p junctions can be collectively energised to emit simultaneously the corresponding wavelengths or colours. The device may be utilised to provide the three primary colours or emit them simultaneously to produce white light.
USE - LED visual display of more than one colour.
2/5

L4 AN 79-72319B [40] WPINDEX
TI White light emitting diode or triode - having semiconductor and semiconductor oxide layers and metal contact pad so that light appears as halo around pad.
DC L03 U12 U14 X26 X26
IN BAYRAKTARO, B M; HARTNAGEL, H L
PA (BAYR-I) BAYRAKTAROGLU B
CYC 1
PI GB 2017409 A 791003 (7940)*
PRAI GB 78-11422 780322; GB 79-13930 790420
AN 79-72319B [40] WPINDEX
AB GB 2017409 A UPAB: 930901
An LED emitting white light when reverse biassed comprises (a) a semiconductor, (b) a layer of semiconductor oxide on teh semiconductor and

(c) a metal pad on the oxide. A double oxide LED comprises an LED as above having a layer of Al2O3 between the metal pad and an oxide of the semiconductor. The Al2O3 oxide of the semiconductor are both 20-70 angstroms thick.
A light emitting triode comprises an LED as above, with a second metal pad spaced from the first metal pad and contacting the semiconductor oxide. Pref. the semiconductor is Si, having ample superficial trap density or III-V or II-VI semiconductors, esp. *n*-type gaAs.
The light appears as a halo round the pad and is continuous over teh visible spectrum and into the infrared. For luminescence over an area a grid electrode or very thin electrode may be used. Typical temp. range of operation is 77-393 K for GaAs device, with higher efficiency at lower temp.

b. Phosphors and LEDs - active layer

i. AN 92:4211991 INSPEC DN B9209-4260D-010
TI Amorphous carbon basis blue light electroluminescent device.
AU Yoshimi, M.; Shimizu, H.; Hattori, K.; Okamoto, H.; Hamakawa, Y. (Fac. of Eng. Sci., Osaka Univ., Japan)
SO Optoelectronics - Devices and Technologies (June 1992) vol.7, no.1, p.69-81. 20 refs.
CODEN: ODTEEG ISSN: 0912-5434
DT Journal
TC Practical; Experimental
CY Japan
LA English
DN B9209-4260D-010
AB Blue light emission has been observed in hydrogenated amorphous carbon (a-C:H) basis multilayered thin-film electroluminescence (EL) mode structure. The device is composed of a-C:H/a-SiC:H active layers sandwiched between hydrogenated amorphous silicon nitride (a-SiN:H) insulating layers, all of which are prepared by RF plasma chemical vapor deposition. A series of technical data on the device performance, including luminance, transferred charge density and emission spectrum are presented. Developed devices exhibit a broad band white light emission having a luminance up to 20 cd/m2. However, purity of emission color is remarkably improved by insertion of a-SiC:H layer in the middle of the active a-C:H layer.

ii. AN 92(10):62808 PHYS
TI Several blue-emitting thin-film electroluminescent devices.
AU Miura, Noboru; Ishikawa, Tetsuo; Sasaki, Takashi; Oka, Toshiyuki; Ohata, Hiroshi; Matsumoto, Hironaga; Nakano, Ryotaro (Dept. of Electronics and Communication, Meiji Univ., Kawasaki (Japan))
SO Jpn. J. Appl. Phys., Pt. 2 (15 Jan 1992) v. 31(1A/B) p. 46-48
ISSN 0021-4922; CODEN JAPLD
CY JAPAN
DT Journal
TC Experimental
LA English
AB Blue-emitting thin-film electroluminescent (EL) devices were studied. As the blue-emitting phosphor, thin-films in which the Tm3+ ion was doped into several hosts (ZnS, Y2O2S, CdF2, ZnF2 and YF3) and CaF2:Eu were

investigated. Blue EL emission of Tm3+ ions arising from the 1D2->3H4 or 1G4->3H6 transition was observed in each Tm-doped device. The most dominant lines in these emissions varied with the kind of host materials. The CaF2:Eu thin-film also showed blue electroluminescence due to a parity-allowed 4f6(7F)5d->4f7(8S) transition of the Eu2+ ion. (orig.)

c. **Upconversion** - this process converts monochromatic (narrow band) light into second or third harmonics of the initial light wavelength and, hence, the efficiency of the light emission is a function of the intensity. Further, the light emission remains monochromatic and can not be used to generate white light. Further, the intensities of current light emitting diodes are not thought to be sufficient to allow for up conversion to practically take place (although the light emission from diode lasers are probably sufficient).

I AN 87:2989562 INSPEC DN A87110582; B87063351
TI Various performances of fiber-optical temperature sensor utilizing infrared-to-visible conversion phosphor.
AU Hirano, M.; Watanabe, M.; Yasuda, H. (Ron Tateisi Electron. Co., Kyoto, Japan)
SO Denki Kagaku (Feb. 1987) vol.55, no.2, p.158-64. 6 refs.
CODEN: DNKKA2 ISSN: 0366-9297
DT Journal
TC Experimental
CY Japan
LA Japanese
DN A87110582; B87083351
AB A fiber-optical temperature sensor utilizing temperature-sensitive emission of an infrared-to-visible conversion phosphor YF3:Yb, Er has been developed. This sensor was successfully applied to temperature measurements in the 3 KW-microwave field. The accuracy of +or-0.5 degrees C over the range of -20 degrees C to +200 degrees C was obtained. It was found that the margin of instrument error included the difference of measured temperature and previously calibrated temperature. The instrument error was compensated by calculating the correction. The precise technique to meet temperature-sensitivity of the probe with its calibration curve has been developed. The thermal drifting in the temperature indication was decreased by the stabilization of an infrared excitation with use of an LED feedback control. This is explained by the fact the efficiency of the phosphor excitation is maintained to be constant by the competitive actions of thermally induced fluctuations in intensity and wavelength of an LED emission. The competitive actions for the YF3:Yb, Er phosphor are effective for the excitation wavelength of 940 to 950 nm.

II. AN 90:177498 HCA
TI Pulse operating up-converting phosphor LED
AU Zdanowski, Marek
CS Inst. Electron Technol., Sci. Prod. Cent. Semicond., Warsaw, Pol.
SO Electron Technol. (1978), 11(3), 49-61
CODEN: ETNTAT; ISSN: 0070-9816
DT Journal
LA English

AB On the basis of a kinetic model of Yb3+-Er3+ system, an anal. was made of the performance of YF3:Yb3+, Er3+ IR-to-visible conversion source with cooperating light emitting diode driven with rectangular current pulses.

III. AN 90:177497 HCA
TI Infrared-to-blue up-converting phosphor
AU Wojciechowski, Jerzy; Pawelska, Irena
CS Inst. Electron Technol., Sci. Prod. Cent. Semicond., Warsaw, Pol.
SO Electron Technol. (1978), 11(3), 31-47
CODEN: ETNTAT; ISSN: 0070-9816
DT Journal
LA English
AB The emission spectrum of the YF3:Yb3+, Tm3+ up-converting phosphor was studied, which resulted in the introduction of schematic manners for both energy transfer and radiative deexcitation in the Yb3+-Tm3+ system. Principal performance characteristics were detd. for such type of up-converting phosphor-light-emitting diode system acting as a blue emission source.

4. Invention

a. Development of a white light emitting diode using a blue or UV light emitting diode die and a fluorescer or combination of fluorophors encapsulated within the plastic encapsulating dome above the active layer of said die. The fluorophors are chosen in such a manner that they absorb the monochromatic light emission from the UV or blue light emitting die and spontaneously emit the absorbed light as fluorescent or phosphorescent light emissions over a broader spectrum and bathochromic to the original wavelength of emission. With the spontaneous re-emission of light over a broad range of wavelengths, the appearance of said light can be adjusted to appear white of any shade or hue.

b. Development of a light emitting diode using a blue or UV light emitting diode die and a fluorescer or combination of fluorophors where the spontaneously emitted fluorescence or phosphorescence is a broad emission and is of any color or hue other than the color of the initial emission from the light emitting diode die.

c. Development of a light emitting diode using a blue or UV light emitting diode die and a segregated assembly of fluorescent or phosphorescent dies such that different portions of the plastic encapsulating dome emits color of different wavelengths and hence provides a multiple color lamp products.

d. Development of a light emitting diode lamp using a blue or UV light emitting diode die whereby the incidence of illumination is dramatically increased by virtue of the spontaneous fluorescence

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and phosphorescence, from the selected dyes, is emanating from a lambertian surface, as opposed to a point source from a single point p-n junction.

e. Development of a light emitting diode lamp using a blue or UV light emitting diode die whereby the color of the spontaneous emission can be varied as a function of ambient temperature (and, hence, the applied voltage) where the fluorescent or phosphorescent dyes emit different wavelengths of emission as a function of temperature.

f. Development of a light emitting diode lamp with a long memory of re-emission of light in such a manner that the re-emitted light continues to be observed for several hours after the applied voltage is removed by the incorporation of suitable phosphorescent materials into the encapsulating matrix.

g. Development of a light emitting diode where an electrical pulse is delivered (to minimize power drain from the battery source) but where a continuous period of illumination is realized by adjustment of the luminescence lifetimes of suitable phosphors;

h. Development of a light emitting diode where the total illuminance is increased by virtue of shifting the illumination wavelenghts of any short wavelength emitting p-n junction towards the photopic maximum.

i. Development of a light emitting diode where a photochromic phosphor is used such that the illumination wavelength during day or night usage is different by virtue of using incident sunlight to adjust the chromaticity of the incorporated dye.

5. Distinction from Prior Art

a. Phosphors are not incorporated into active layer thereby not impacting the inherent efficiencies of the p-n junction;

b. White light emission can be obtained using one addressable die;

c. Different shades and hues can be obtained from the same underlying diode die by modifying the encapsulating material which occurs later in the manufacturing process;

d. Colors and shades are not limited to monochromatic emissions, although they could be designed as such;

e. Efficiencies of light emission are not intensity dependent as in up - conversion.

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f. Selection of fluorophors and phosphors are not limited to those that are compatible with active layer;

g. Incidence of illumination can be improved and broadened over a greater range than available from any other method presently used in LED fabrication;

h. Potential for lasing to take place within dome?

i. opportunity to develop lambertian surface emission from an otherwise point source.

6. Details of Method

a. Blue or UV light-emitting diode die, made from a GaN or SiC or any other semiconductor known to produce UV or blue light is cut;

b. Die is potted into an encapsulating dome containing mixture or specially designed fluorophor or phosphor;

c. Concentration and path length of dome is selected to maximize the emission yields and color.

7. Claims

Patent Introduction:

Considerable efforts have been advanced in the area of developing full-color and white light emitting diode systems to replace existing illumination devices based on incandescent and fluorescent (mercury vapor) bulbs. The practical advantages of illumination devices based on light emitting diodes are many and include higher reliability, lower power consumption, shock resistance, longer illumination duration, discrete wavelengths of illumination and focused illumination output. It is important to note, however, that certain of these practical advantages can be considered design disadvantages in the context of special systems. For example, whereas the focused light output from a typical light emitting diode allows for alignment of the light intensity without requiring a sophisticated and expensive lens system, in those applications where the illumination needs to be observed across a wide face, the requirement to defocus the other illumination cone is clearly a disadvantage.

One application where light emitting diodes are beginning to become an accepted replacement for incandescent bulbs is in the area of electronic message signs used to supply advertising media as well as the current time and temperature. Many of these signs are resident in the outdoors and need to be bright

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enough to be observed in the daylight and from a suitable distance. In most cases, existing outdoor signs have relied upon incandescent lamps which, because of their broad spectroscopic illumination profile, are observed to illuminate in a white color. For these outdoor applications, the light emitting diodes provide a tremendous advantage in that their burn time is in excess of ten years, whereas incandescence frequently "burn out" and, thus, leave an empty pixel in the message. In real world applications, the burn out of the pixel makes the message unreadable or, at best, provides a significant maintenance component to the management of the outdoor signs.

Current usage's of light emitting diodes in outdoor and other signage have been restricted to either red or amber illumination colors. Although other monochromatic colors are available, the intensity of the light emitting diode needs to be in excess of 1000 mcd and, hence, have been limited to hard to visualize colors. Further, the aesthetics of signage in monochromatic colors of red and amber have limited their acceptance as replacements for white incandescent lamps, despite the maintenance and low power consumption advantages of the light emitting diode, in general.

White light can, in theory be presented in outdoor light emitting diode assemblies, but presently, the broad band illumination necessary to provide white light requires the use of many light emitting diode lamps incorporated into complicated LED modules. In many cases, the modules contain at least 8 and up to 22 components where blue, green and red light emitting diode lamps are electrically powered and manipulated in such a manner as to provide the appropriate balance of monochromatic light blended in such a manner as to provide a white light source. The high cost and low efficiency of these modules make them relatively unattractive as replacements for single incandescent white lamps and hence, the availability of white light emitting diode lamps, especially based on single semiconductor dice, are highly wanted.

It is the claim of this invention that single semiconductor dice can be incorporated into a simple light emitting diode "pot", that has been incorporated with fluorescent organic and inorganic fluorescers and phosphors that take either the blue or ultraviolet radiation of the pot and provide a substantial series of benefits. One major unexpected advantage of using this process to attenuate the monochromatic light normally emitted by a light emitting diode is the development of a simple device that yields a broad band emission, in total, bathochromic to the initial wavelength of emission, and is emitted with the appearance of white light. Further, this invention will allow for the direct replacement of simple incandescent white lamps bulbs with simple, single light emitting diode lamps that similarly provide a white light emission but which incorporated all of the other advantages of light emitting diodes.

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